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SMALL HYDROELECTRIC POWER PLANTS IN  
RURAL AREAS OF NORTH KOREA

By No Chin-p'11

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PROBLEMS IN THE CONSTRUCTION OF SMALL  
HYDROELECTRIC POWER PLANTS IN RURAL AREAS OF  
NORTH KOREA

[This is a translation of an article written by NO Chin-p'il, in Ch'ollyok (Electric Power), No 7, July 1959, P'yongyang, pages 47-51.]

The numerous small hydroelectric power plants built in the rural areas of our country can, in general, be divided into two kinds: those power plants which have a water-wheel-type (such'a) turbine, and those which have a propeller-type (p'uop'era) turbine made of wood or steel. Both types are used in power plants that have a head of about six meters.

In a considerable number of cases, however, these small hydroelectric power plants are deficient in quality, and there are even some plants which were abandoned after they had been put into operation.

Why, then, are these power plants not operated regularly in a considerable number of cases?

This question, first of all, raises the problem of selecting the right site for a power plant and of installing it adequately.

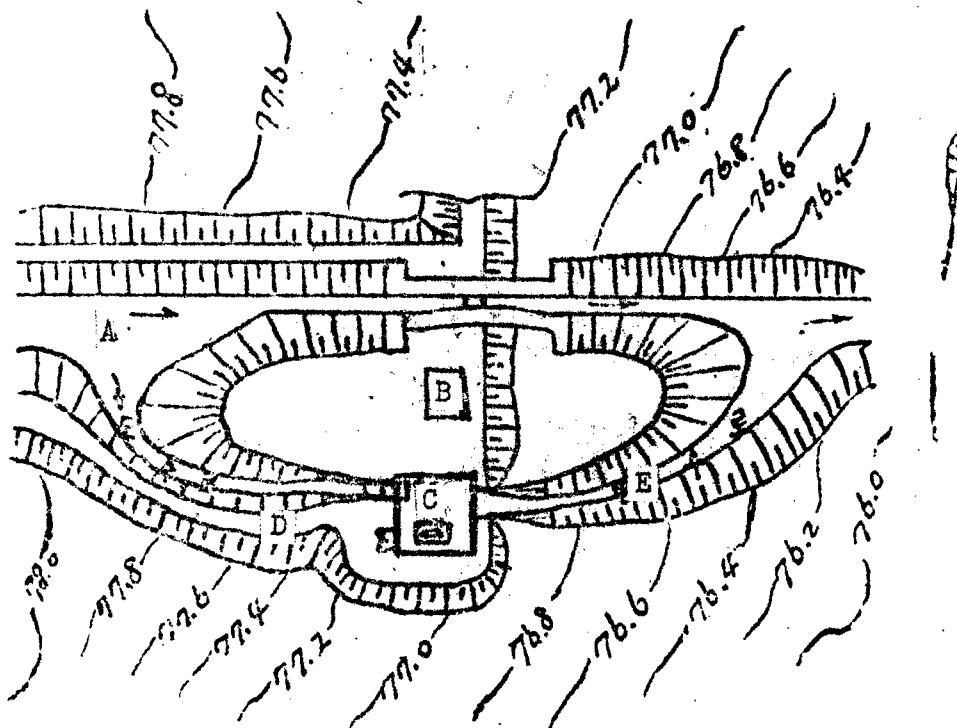
There are two basic requirements for the selection of a site. One is to obtain the maximum amount of electricity from a small investment and from small-scale construction work by maximizing the utilization of water resources; the other is to maintain the regular production of electricity through the continuous supply of a constant quantity of water, irrespective of increases or decreases in the water volume of rivers.

In connection with the installation of power plants, an essential point to be kept in mind is that they must be closely linked with the irrigation of paddies and dry fields.

However, some of the power plants already built have not been properly linked with the irrigation of paddies and dry fields, although geographical surroundings were, in general, well utilized in the selection of power-plant sites.

Of the power plants which ceased operation because of a lack of water supply, more than one half of the cases were caused by a separate supply of water to paddies.

At present, the power plants already built are installed as shown in Figure 1; the water is drawn from the upper stream of the river and, after passing through the power plant, it is released directly into the lower stream of the river, thus making it impossible to use the water for the irrigation of paddies and dry fields.



A- Irrigation Waterway

B- Pole-type (chusang)  
Transformer

C- Power Plant Machine Room

D- Induction Waterway (Tosure

E- Drain

Figure 1

In order to eliminate such shortcomings, the following points, in addition to already known principles, should be kept in mind in the installation of power plants:

The locations for power plants should be selected at a point as far up in the upper stream as possible. This will make it possible to facilitate the supply of the water released through the drains [of the plant] to paddies and dry fields along the lower stream.

For this purpose, it is better to link the drain of the power plant directly with the irrigation waterway. [This is precisely the technique shown in Figure 1. It is not too clear why the water released through the power plant, as shown in Figure 1, cannot be used for irrigation, since the drain of the plant is connected with the irrigation waterway as is indicated by arrows.]

Moreover, to supply water to paddies and dry fields continuously, even when the power plant is not in operation, a sluice gate should be installed at the induction waterway (tosuro), thereby connecting it with the irrigation waterway. In other words, it is better to connect the route for the surplus water (yosuro) of the power plant directly with the irrigation waterway.

Where it is not feasible to connect the drain of the power plant directly with the irrigation waterway when the power is in operation, a lock (po) must be installed at the lower side of the drain, so that the water can be drawn into the irrigation waterway.

In such a case, water can be supplied to paddies and dry fields while the power plant is kept in continuous operation. A power plant which meets all these requirements is illustrated in Figure 2.

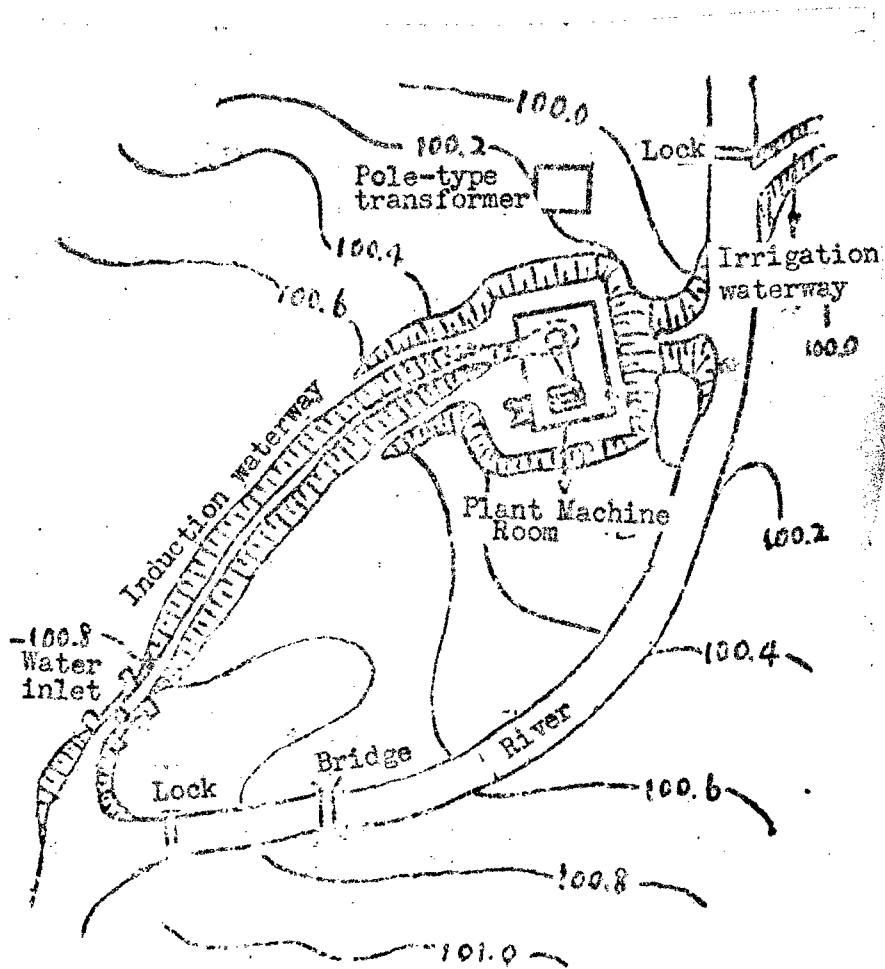


Figure 2

Secondly, there is a problem related to the volume of water.

The problem of determining the volume of water available to the power plant is a very important one, for water is the basic element conditioning the output of electricity by the power plant. In general, the greater the volume of available water, the more electricity a power plant can generate. The determination of the water volume available to the power plant should be made with a view toward maximizing the utilization of river water.

To this end, even if there is nothing to speak of in the way of sluice-gate data, at least a general determination of the volume of the river water should be made by measuring the flow during both the rainy period and the drought period of the year.

The experience of plants already built indicates that very often these plants make a theoretical determination of the water volume, without any measurement data whatsoever. Some of the power plants even installed water wheels uniformly, with the same diameter, without taking into consideration the water volume required by the plants. The inevitable result was that these water wheels could not draw in an adequate volume of water and, hence, the plants ceased to operate.

In addition to the above-mentioned advance measurement of the waters flow, there are some other methods which may be applied to eliminate such shortcomings. One of them is to save the available water and to put it to effective use. To this end, water volume should be controlled. But none of the power plants thus far built has a water control system.

Without adequate water control, severe fluctuations in the output of electricity cannot be avoided. For this reason, those power plants which have already been built, as well as those which are to be built in the future, should construct the appropriate structures for the control of water volume. To this end, a power plant should have a defined reservoir capacity.

It is recommended that, to reduce fluctuations in the output of electricity, a small power plant should have a reservoir capacity the equivalent of from 2/10,000 to 2/1,000 of the annual flow of the river utilized. More concretely stated, during a drought season, it should store water during the day so that it can operate for about 12 hours during the night, or, conversely, it should store water during the night so that it can operate during the day.

At that time, the required reservoir capacity can be determined by multiplying the [unit] water volume used by the length of operation time (in seconds).

Even in such a case, water for irrigation purposes should, of course, be released by the plant toward the lower side.

Another requirement is to prevent the loss of water at intermediary points! Loss of water at intermediary points is mainly due to inadequate waterways! In some power plants, 0.2 cubic meter of water drawn through inlets is reduced to only 0.1 cubic meter when the water reaches the turbine room (such as I). The water can penetrate and come through easily, since many small power plants are built in mountain regions, and since the soil used for their structure contains a great deal of sand and gravel.

For this reason, it is necessary to pound and harden the structure of waterways.

If all these requirements are met, the problem of a water shortage can be solved.

Thirdly, there is the problem of selecting adequate types (hyongsik) of power plants, which mainly consists of determining the type of turbine that should be used; also involved in this problem is the selection of a type of turbine which will ensure the maximum output of electricity with equal head and water volume.

Currently, however, water wheels account for a major portion of the turbines.

We will consider first the water wheels which have already been built in large numbers; these have been installed, as indicated in Figure 3, with the water falling upon a wing at the upper end of the water wheel.

[Figure 3 follows.]

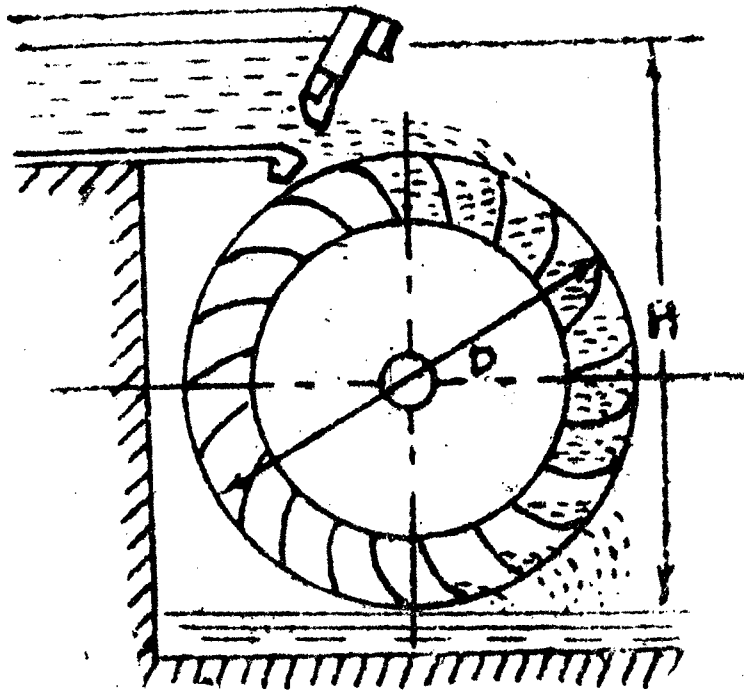


Figure 3  
Installation of a Water Wheel



As the previous illustration indicates, the basic defect of the water wheel is that it cannot fully utilize the force of the water. Even where the water wheel is well built, at best it can utilize only 30 to 40 percent of the water force. From the standpoint of the head, water wheels cannot be used effectively when the head is less than 3.0-3.5 meters; since most of the water wheel so far built have a head of only 1.5-2.5 meters, they have been all the more ineffective.

Next, it should be pointed out that the electric motor system (chongdong changch'i) is inadequate. The ordinary frequency of revolution of a water wheel, with load, approximates 12 rpm. But as the speed required by the generator demands a high frequency of revolution, it is necessary to have a complicated electric motor system, if only to meet this requirement.

Although most of the water wheels already built in the water-wheel [turbine] type power plants are made of the roots of the "samdan" [a kind of tree?], they are still unable to ensure the frequency of revolution required by the generator.

In view of these facts, it follows that with water wheels, it is impossible to utilize the water force fully, and that granted the use of a part of the water force (30 to 40 percent), it is also impossible to produce electricity of good quality.

At present, the production of the roots [of the "samdan"] and belts (p'idae) to be used by the small hydroelectric power plants in rural areas has not been standardized.

At present, the belt [operated] electric motor system is very rudimentary. Losses caused by this electric motor system account for a considerable portion of the total loss. Thus, the net result is that the construction cost per kilowatt of electricity is high.

For the systematic utilization of the water force of rivers, therefore, the water wheels thus far built should be gradually replaced by the new propeller type turbines, and the small power plants to be built in the future should utilize these propeller-type turbines for the production of electricity.

By constructing a small power plant with a propeller-type turbine, Puhari [Agricultural Cooperative], Yongan-gun, Hamgyong-pukto, has been able to produce 15 kilowatts of electricity, thereby both providing light for 150 farming families and operating its rice mill and lumber mill.

Our experience indicates that the propeller turbine possesses a considerable advantage over the water wheel. For example, while the water wheel utilizes only 30 to 40 percent of the water force for the production of electricity, the propeller turbine utilizes up to 70 to 80 percent of the of the water force under the same conditions. Regrettably, however, a total of only eight power plants equipped with such propeller-type turbines have been built in Hwanghae-pukto and P'yongan-namdo.

The fundamental defects of the power plants which have installed propeller turbines will be referred to below.

Figure 4 illustrates the section of a small hydroelectric power plant built according to the standard design. The turbine used here is of the propeller type, and it is made of either wood or steel.

[Figure 4 follows.]

Sectional diagram of  
a small hydroelectric  
power plant

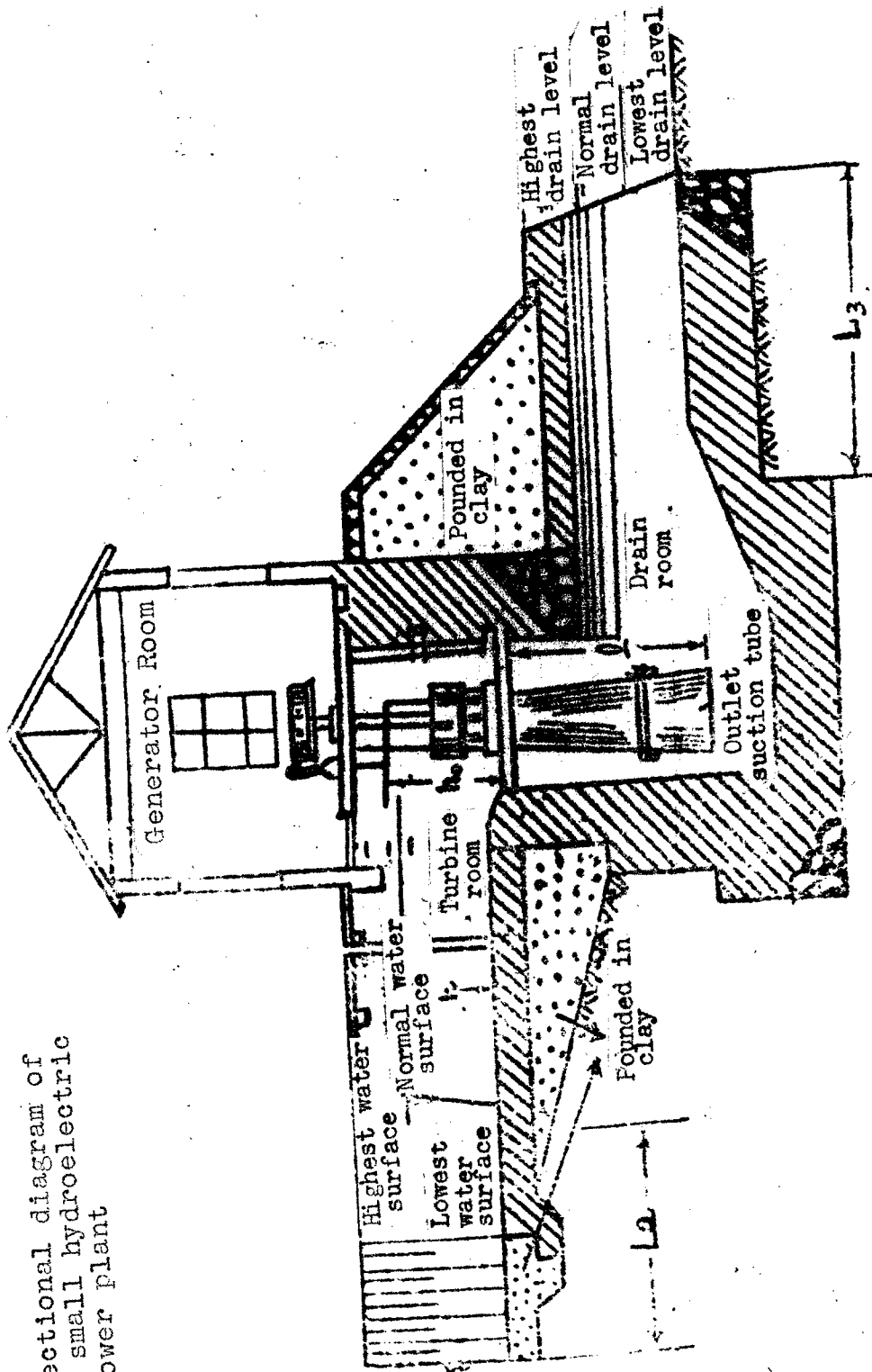


Figure 4

- L2 - length of a section in which the wet earth is pounded in to prevent leakage of water
- ho - height of water level in turbine room
- L3 - Length of a section in which wet earth is pounded in to prevent leakage of water (lower axle)

Reference will be made here mainly to the structure of a small power plant equipped with a propeller-type turbine. Although they have installed good turbines, some power plants are no longer in operation because of inadequate structures (kujomul).

The most important part of the structures of a power plant is the part which is submerged in the water. Unless this part is well built, the efficiency of the turbine may be reduced. Some of the power plants already built have turbine rooms (such'asil) which do not meet specifications.

For example, it is required that a certain height be maintained from the bottom to the water surface in the turbine room. Under normal conditions of operation, the numerical value of this height is from 1.2 to 3.1 meters. But some power plants maintain only 30 centimeters between the upper edge of the turbine and the water surface.

As a result, air can penetrate through. As for the base of the turbine room, it is built, in many cases, with wood, and a considerable amount of water flows out through the space between the boards. The same is true of the outlet suction tube (hupch'ulgwan).

Absolutely no air should be allowed to penetrate into the outlet suction tube. The outlet suction tube has been unable to perform its required function fully precisely because of the penetration of air into the tube through the space between the boards.

The continuous low efficiency of the power plants which have installed propeller turbines has, no doubt, been caused either by the inadequate wings of the turbines or by the poor quality of the metals used for them. However, it is also greatly affected by the defects mentioned previously.

An adequate vacuum state should be ensured inside the outlet suction tube. An adequate water level must be maintained in the turbine room, and, if the water leaks out through the bottom of the turbine room and the air penetrates into the outlet suction tube, we cannot obtain good results, no matter how good a turbine is installed.

Care and thoroughness must be exercised in the construction of the turbine room, and particularly in the construction of its base, in order to prevent the leakage of water and the penetration of air.

Next, there is a problem related to the foundation of the power plant.

Because their foundations were submerged not long after construction, the entire structure of some power plants, or the axles of their turbines, bent downward, thereby causing a complete stoppage of power production.

Such a phenomenon can have two causes. In one case, the foundation was not laid over a space sufficient to support the total load of the building and facilities of the power plant; in the other, the foundation collapsed because of water penetration from both above and below the foundation. The principal cause in both cases was the failure to prevent the penetration of water at the time of the construction of the foundation.

L2 and L3 in Figure 4 are the lengths of the upper and lower sections of the foundation; the pounding and filling of wet earth are absolutely required here in order to prevent the penetration of water into the foundation. These indispensable lengths are two to six meters for the upper section of the foundation and five to eight meters for the lower section below the drain.

The method of pounding in the wet earth is to pound and fill, in each operation, a layer about 15 centimeters thick, and to continue pounding one layer upon another.

Unless this requirement is thoroughly met, the foundation of the power plant will be very weak, and the loss of water on the way will be great, thus preventing the turbine room from securing an adequate water level.

Finally, there remains the problem of improving the maintenance of the entire building of the power plant. The buildings of some power plants were in such poor condition that the generators were exposed to rain and became all but unusable. In some cases, the buildings were very ugly--from the floor through the walls and up to the roof of the generator room.

A power plant should be built at low cost, but it must be sturdy, clean, and of high utility. There are good building materials abundantly available in the rural areas of our country. High-quality granite, magnesium cement (sokbirye), clay, lime, and cement are the building materials which are readily available in rural areas.

An excellent power plant probably can be built, if these resources are mobilized and are well utilized.

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